NASA DEVELOP Students Rev Up Response to Gulf Oil Spill

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NASA Responds to the *Deepwater Horizon* Oil Spill

After the April 20th explosion aboard the *Deepwater Horizon* drilling rig in the Gulf of Mexico, the world witnessed one of the worst oil spill catastrophes in global history. In an effort to mitigate the disaster, the U.S. government moved quickly to establish a unified command for responding to the spill. Some of the command's most immediate needs were to track the movement of the surface oil slick, establish a baseline measurement of pre-oil coastal ecosystem conditions, and assess potential air quality and water hazards related to the spill. To help address these needs and assist the Federal response to the disaster, NASA deployed several of its airborne and satellite research sensors to collect an unprecedented amount of remotely-sensed data over the Gulf of Mexico region. Although some of these data were shared with the public via the media, much of the NASA data on the disaster was not well known to the Gulf Coast community. The need existed to inform the general public about these datasets and help improve understanding about how NASA's science research was contributing to oil spill response and recovery. With its extensive experience conducting community-oriented remote sensing projects and close ties to organizations around Gulf of Mexico, the NASA DEVELOP National Program stood in a unique position to meet this need.

DEVELOP Initiates Regional Public Outreach Campaign

DEVELOP is a NASA Science Mission Directorate Applied Sciences training and development program. Mentored by science advisors from NASA and partner agencies, students conduct applied remote sensing projects and demonstrate the relevance of their research to local policy makers. During the *Deepwater Horizon* oil spill crisis, DEVELOP students capitalized on their collective science research and community outreach skills to initiate public campaign across the Gulf Coast highlighting NASA's contributions to oil spill response, recovery, and research. The DEVELOP Oil Spill Outreach team consisted of students from DEVELOP's offices at Stennis Space Center (SSC) in Mississippi, the Mobile County Health Department (MCHD) in Alabama, and Langley Research Center (LaRC) in Virginia.

The team's first objective was to add value to some of NASA's existing online satellite data by making it easier for the public to interpret and understand. They accomplished this goal during the summer by creating visually appealing, simple animations of imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's *Terra* and *Aqua* satellites and from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument onboard NASA's *CALIPSO* satellite. Using select daily MODIS imagery from Goddard Space Flight Center's (GSFC) MODIS Rapid Response System, the students created a time-series animation showing how the surface oil slick changed shape and location throughout the summer. By modifying geographic information system (GIS) shapefile data acquired from the National Oceanic and Atmospheric Administration (NOAA), the students created cartographic contours that more clearly depicted the distance of the oil slick from well-known coastal cities that improved previous visualizations. Combined with animated images these contour lines can help the general public can more easily interpret how the oil slick was moving (Figure 1). Similarly, the students produced a virtual video that takes viewers on a flying 3D tour of CALIOP's atmospheric aerosol data over the Gulf of Mexico. Enhanced with background imagery from MODIS and even a 3D model of the *Deepwater Horizon* drilling platform, the visualization helps users better understand how CALIOP aerosol data can be used to study potential air pollutants related to the oil spill (Figure2). These data visualizations can be accessed at the DEVELOP website develop.larc.nasa.gov.

In addition to creating satellite data animations, the students also contributed to a "one-pager" fact sheet that the NASA Langley Public Outreach Office published highlighting NASA's oil spill imagery and research activities. Moreover, the DEVELOP team created a conference poster and presentation summarizing NASA's oil spill data products and some of the fascinating research being conducted using the data. Finally, the students drafted a public information sheet with lists of websites for oil spill information and data. Equipped with these outreach tools and science data visualizations, the team set out on a public awareness tour in Louisiana, Mississippi, Alabama, and Florida to educate Gulf Coast residents on ways that NASA science is making positive contributions to local communities.

Before reaching out to the general public, the team focused on informing scientific/technical staff from regional academic, government, and private-sector organizations about ways that NASA remote sensing data could enhance their oil spill response activities. To accomplish this goal, the students attended the Governor's Action Plan Implementation Workshop in Biloxi, Mississippi, organized by the Gulf of Mexico Alliance (GOMA) in early August. Consisting of membership from thirteen federal agencies, all five Gulf States, and four regional research organizations, GOMA exists to promote both the economic and ecologic well-being of the Gulf of Mexico and its surrounding states / countries. With representatives from each of GOMA's member states, agencies, and organizations present, the Governor's Action Plan Implementation Workshop provided DEVELOP a platform for interacting with key stakeholders in the Gulf of Mexico region. The students set up an information booth, presented a NASA oil spill poster, distributed NASA oil spill fact sheets, and answered attendees' questions regarding ways that NASA's remote sensing data products can benefit their organizations (Figure 3). After the workshop, DEVELOP received requests from conference attendees for further information and data. The students were able to direct them to appropriate NASA officials for answering their questions in detail and supplying them with data.

After attending the GOMA workshop, the DEVELOP team began their NASA oil spill "public campaign," giving presentations at the University of New Orleans, the University of Southern Mississippi, the University of South Alabama, and the University of West Florida. They also presented at other venues including the Lions Club in Mobile, Alabama; the Mississippi Association for Spatial Technologies in Gulfport, Mississippi; and the Coast Guard Auxiliary Flotilla in Pass Christian, Mississippi. At each venue, the team presented an overview of the NASA data collected over the *Deepwater Horizon* oil spill and highlighted many of the ongoing scientific research projects that are benefitting from the datasets.

Examples of NASA Data Products and Research that DEVELOP Publicized

In response to the oil spill, NASA acquired imagery and data from numerous spaceborne and airborne sensors. Besides the MODIS and CALIOP data already mentioned, NASA also captured imagery from space using the Multi-angle Imaging Spectroradiometer (MISR), the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), the Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), Jason-1, and the Ocean Surface Topography Mission (OSTM) / Jason-2. NASA also deployed several of its aircraft to collect data using the High Spectral Resolution Lidar (HSRL), the Airborne Visible / Infrared Imaging Spectrometer (AVIRIS), and the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR). See Figures 4, 5, 6, and 7, as well as Table 1 for examples of these sensors and their applications.

The data that NASA collected are useful for many oil spill applications. For example, NOAA image analysts used MODIS imagery when creating their daily oil slick location maps (Figure 7). Scientists at NASA's Jet Propulsion Laboratory (JPL) experimented with radar data from UAVSAR to examine the impacts of beached oil on coastal wetlands, and researchers at LaRC tested the application of HSRL data for detecting sub-surface oil. Additionally, faculty from the University of California at Santa Barbara and the University of California at Davis worked with NASA and the U.S. Geological Survey (USGS) using

AVIRIS imagery to map the thickness of the surface oil slick, characterize the vegetation species of Louisiana's coastal wetlands, and analyze the impacts of washed up oil on those coastal wetlands. These are only a few examples of work being done with NASA data. Several other research projects utilizing the data have also been completed or are currently in progress.

The Community Benefits from DEVELOP's Public Awareness Efforts

The DEVELOP team strove to dispel the notion that NASA focuses only on space and aeronautics research. Through their outreach, the students helped increase awareness among Gulf Coast citizens about NASA's extensive involvement with Earth science and the relevance of NASA science missions to their local communities. The team also informed their audiences about how other agencies and universities are benefitting from NASA's oil spill remote sensing data. For example, the students presented about how NOAA, the USGS, and several universities across the U.S. are conducting oil spill research using NASA remote sensing data products. Communities benefitted from DEVELOP's outreach tour because the public gained a better understanding NASA's Earth Science mission and the impacts that NASA research activities have on their local communities.

DEVELOP Conducts Scientific Research Regarding Oil Spill Impacts to Gulf of Mexico Region

While DEVELOP's initial contribution to NASA's oil spill response was forming a public outreach team, DEVELOP did not stop there. Several of the program's national teams also investigated opportunities for conducting their own scientific and technical research related to oil spill's impact on the Gulf of Mexico environment. The teams proposed multiple student projects to NASA's Applied Sciences Program focusing on a variety of topics. These included potential impacts of the oil spill on air quality and public health, fish populations, and barrier island ecosystems. DEVELOP received approval for five of these projects in Summer 2010 and conducted their research during the Fall 2010 DEVELOP project term. Each of the student teams presented their results to partnering organizations as well as at NASA Headquarters. Additionally, many of the students will go on to present their work at other scientific and policy conferences and meetings nationwide.

Stennis Space Center DEVELOP Project

This project explored the applicability of using the Ozone Monitoring Instrument (OMI) and Tropospheric Emission Spectrometer (TES) onboard NASA's *Aura* mission and the MODIS sensor onboard NASA's *Terra* and *Aqua* missions, to measure the concentration of atmospheric pollutants such as tropospheric ozone and particulate matter levels along the Gulf Coast in relation to the *Deepwater Horizon* oil spill. The team utilized the sulfur dioxide and formaldehyde data products from OMI in conjunction with the ozone and carbon monoxide products from TES, as well as the MODIS aerosol optical depth (AOD), ozone, and particulate matter data products. This project partnered with the U.S. Environmental Protection Agency (EPA) Region 6 *Deepwater Horizon* Oil Spill Air Committee in order to provide a methodology for enhanced air quality monitoring over large geographic areas where no *in situ* sampling data may be available if another oil spill occurs.

Mobile County Health Department DEVELOP Project

The Mobile DEVELOP team focused two projects on oil spill-related topics in the fall of 2010. The first investigated the use of NASA remote sensing products for monitoring anthropogenic sand dune movement on Dauphin Island, Alabama. Sand was brought in as part of the oil prevention effort, but the impact on the island's ecosystems was unclear. The student team's research assessed the impact of the oil prevention project on the island, and provided the partners (Dauphin Island Park and Beach Board and Dauphin Island Sea Lab) with methodologies to use NASA Earth Observing Systems (EOS) to assist in future land management and decision-making. The second project focused on the creation of an inventory and database of NASA remote sensing data products relating to the oil spill for future reference in regards to potential oil spills worldwide. They also collected public health records for correlation with the air quality measurements the SSC and LaRC air quality projects tracked.

Langley Research Center DEVELOP Project
In combination with the Stennis Gulf Air Quality project, the Langley DEVELOP team investigated the use of *CALIPSO*'s Level 2 Version 3.01 Aerosol Extinction data to measure air quality in the oil spill area. The HYSPLIT model was used to track smoke plume trajectories and their distance to populated areas in the Gulf Coast. The goal of the project was to assist the EPA Region 6 with enhanced aerosol monitoring capabilities where no *in situ* datasets were available and assist in the improved regulation of oil spill burning in future spills.

Jet Propulsion Laboratory DEVELOP Project
The JPL DEVELOP fall project focused on the demonstration of synthetic aperture radar (SAR) data to detect oil floating on the surface of water and improve understanding of the *Deepwater Horizon* oil spill impact on the Bluefin Tuna breeding habitat. The team partnered with NOAA and Roffer's Ocean Fishing Forecasting Service, who are researching remote sensing capabilities of assessing populations of Bluefin Tuna and reducing variance in spawning stock abundance in the Gulf of Mexico. This study assessed SAR contributions to decision support efforts relevant to commercial fisheries through the improvement of the understanding of environmental conditions that affect the Bluefin Tuna.

Conclusion
In the summer and fall of 2010, several DEVELOP teams worked to increase understanding of how NASA satellite data help mitigate effects of one of the worst oil spill disasters in history. These teams worked to make NASA satellite data from the *Deepwater Horizon* oil spill more accessible to the general public through the use of animated satellite imagery and one page fact sheets. They also reached out to the science and technical communities to investigate the feasibility of using NASA satellites to enhance oil spill response activities. To examine the feasibility of using these sensors in oil spill response / recovery efforts, different DEVELOP teams focused on various aspects of the oil spill including water and air quality, Bluefin tuna habitats, and public health records. DEVELOP will continue to work on understanding the impact that this oil spill has on the natural environment including wetlands, national reserves, and endangered species population through the use of NASA EOS.

DEVELOP Plans Future Oil Spill Related Research
The *Deepwater Horizon* oil spill allowed approximately 185 million gallons according to *Science Magazine* of crude oil to flow into the Gulf of Mexico over an extended period of time, the full impact of which is yet to be seen. The spill caused extensive damage to marine and wildlife habitats, and even the repercussions of protection schemes of containment and dispersants are not clearly understood. DEVELOP teams are continuing research in the Gulf of Mexico to improve understanding of the impact to wetlands, marshes, national reserves, and endangered species populations. DEVELOP teams continue to explore how NASA's Earth observations can assist in the decision making process and policy relating to future oil spills. The results of these future DEVELOP projects and others will be presented at local, state, and regional scientific and policy-oriented conferences in the upcoming months.

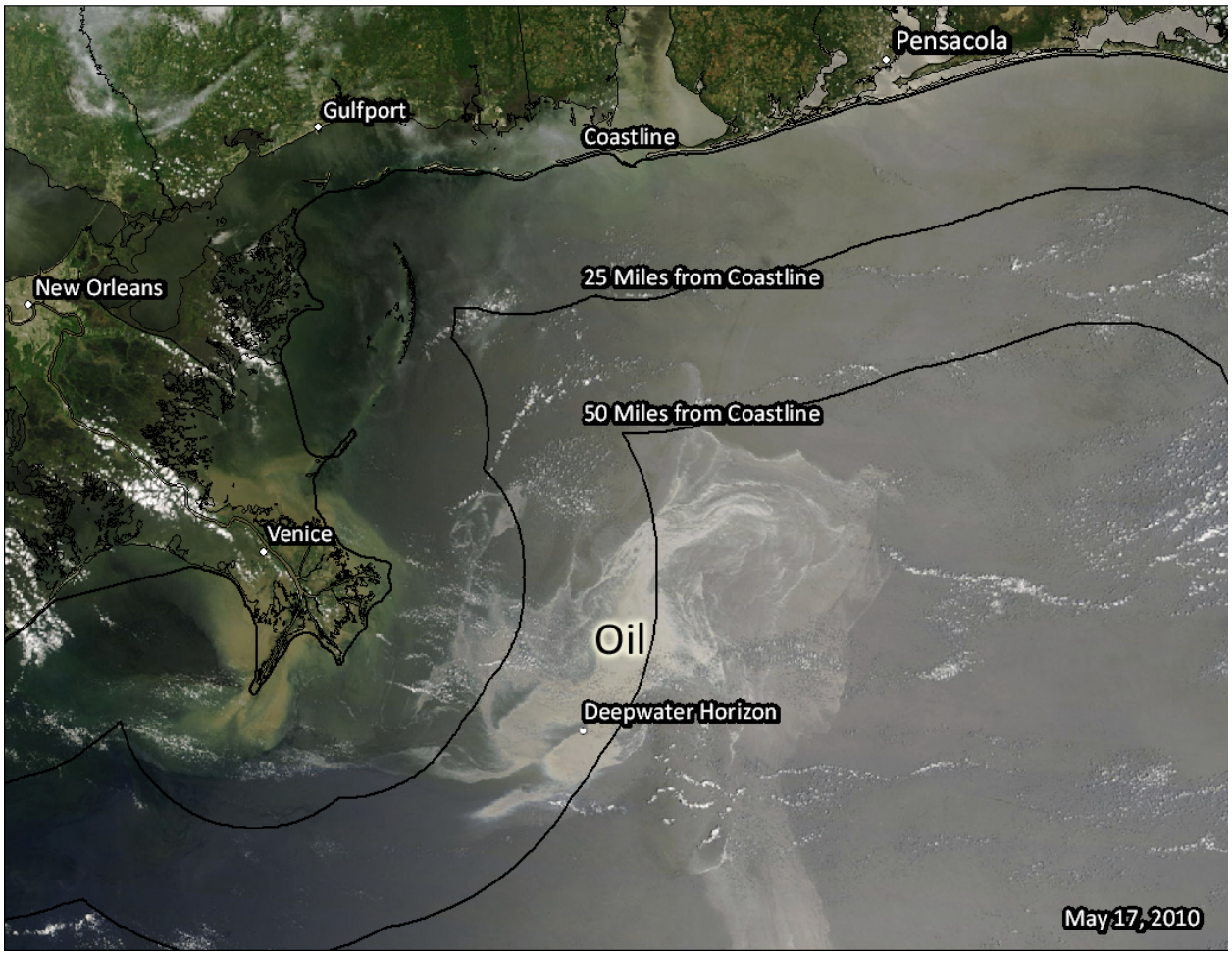

Figure 1 – *Terra* MODIS Image of *Deepwater Horizon* Oil Slick in the Gulf of Mexico on May 17, 2010. Image Credit: NASA/GSFC, MODIS Rapid Response. Cartography Credit: NASA DEVELOP.

Figure 2 –Still Frame from DEVELOP's *CALIPSO* CALIOP Visualization. CALIOP Data Tracks are Overlaid on a Background MODIS Image.

Figure 3: Josh Stodghill (Left) and Jamie Favors (Right) Represent DEVELOP at the Gulf of Mexico Alliance Governor's Action Plan Implementation Workshop in Biloxi, Mississippi, August 3, 2010. Photo Credit: Jason Jones, NASA DEVELOP National Program.

Figure 4: ASTER Image Showing Oil Slick Approaching the Mississippi River Delta in Southeastern Louisiana on May 24, 2010. Oil Appears as White Sheen. Image Credit: NASA. Annotation by NASA DEVELOP.

Figure 5: NASA's Earth Resources-2 (ER-2) Aircraft Carrying the AVIRIS Sensor. Image Credit: NASA.

Figure 6: NASA's Gulfstream G-III Aircraft with UAVSAR Mounted Underneath. Image Credit: NASA.

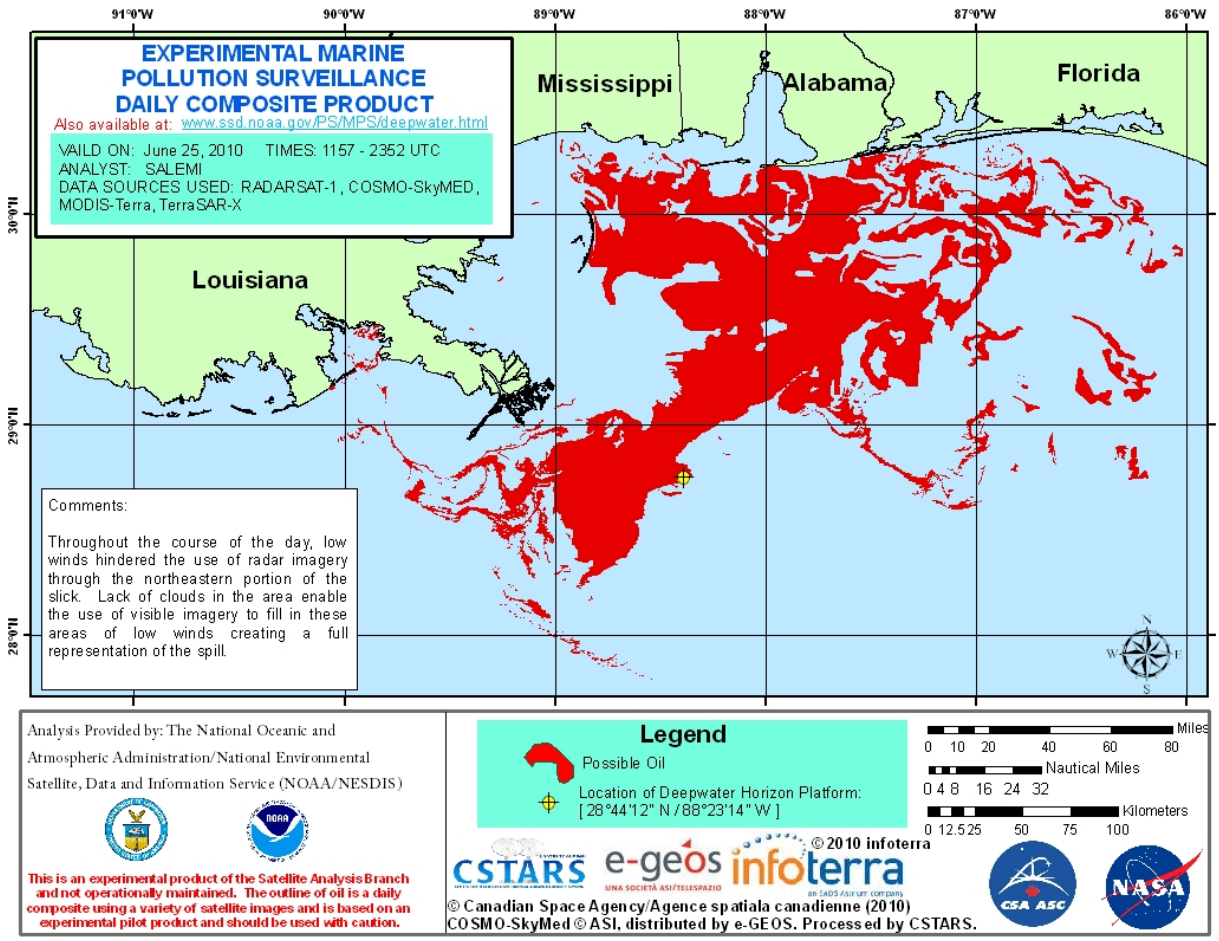

Figure 7: Example of a NOAA Oil Spill Map Generated from MODIS and Other Sensor Data. Image Credit: NOAA.

NASA Airborne Sensors:		
Sensor	**Applications**	**User**
High Spectral Resolution Lidar	Tracking Air Pollution, Detecting Sub-surface Oil, and Studying Phytoplankton	NASA
Airborne Visible / Infrared Imaging Spectrometer	Analyzing Surface Oil Thickness, Mapping Marsh Grass Species, and Assessing Coastal Wetlands Health	NASA, U.S. Geological Survey, University of California Santa Barbara, and the University of California Davis
Uninhabited Aerial Vehicle Synthetic Aperture Radar	Evaluating Oil Impacts on Coastal Marshes	NASA
NASA Spaceborne Sensors:		
Sensor	**Applications**	
Moderate Resolution Imaging Spectroradiometer	Tracking Surface Oil Location / Movement, Monitoring Wetlands Health, Studying Harmful Algal Blooms, etc.	NASA, National Oceanic and Atmospheric Administration, and the Navy Research Laboratory
Cloud-Aerosol Lidar with Orthogonal Polarization	Studying Air Quality and Detecting Surface Oil	NASA and the Navy Research Laboratory
Multi-angle Imaging SpectroRadiometer	Delineating Surface Oil Slick	NASA
Advanced Spaceborne Thermal Emission and Reflection Radiometer	Tracking Surface Oil and Monitoring Coastal Wetlands Health	NASA
Thematic Mapper / Enhanced Thematic Mapper Plus	Tracking Surface Oil and Monitoring Coastal Wetlands Health	NASA and the U.S. Geological Survey
Advanced Land Imager	Tracking Surface Oil and Monitoring Coastal Wetlands Health	NASA
Jason-1	Measuring Sea Surface Height and Studying Ocean Currents	NASA and the University of Colorado
Ocean Surface Topography Mission / Jason-2	Measuring Sea Surface Height and Studying Ocean Currents	NASA and the University of Colorado
International Space Station Photographs	Delineating Surface Oil Slick	NASA

Table 1: NASA Sensor Coastal Application Summary. This table provides an overview of many of the primary oil spill sensors, applications, and users; however, it may not accurately portray all oil spill remote sensing data or research activities.